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ABSTRACT

An important area of study for many researchers in science education is how attitudes are formed and manifested, including the relationships between environmental influences and attitude formation among students. This literature search was conducted in an attempt to identify the variables which may affect students' attitudes toward science, and to describe the extent to which the variables affect attitudes. The major portion of this document contains abstracts of articles. The first part of the study examines attitudes toward scientific interests, referring to those interests that students have in common with scientists. The second category includes attitudes as an approach to thinking about science, focusing on cognitive attitudes. The third category dealt with attitudes toward the subject matter of science. In the final section, attitudes as affected by teaching methods were examined. (TW)

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# AN ANNOTATED BIBLIOGRAPHY OF THE LITERATURE DEALING WITH VARIABLES AFFECTING STUDENTS' ATTITUDES TOWARD SCIENCE

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# INTRODUCTION

An important area of study for many researchers in science education was how attitudes were formed and manifested. Of particular concern were the relationships between important environmental influences and attitude formation among students. It was believed that policy changes could be made that would affect curriculum and instruction in science classes as more was understood concerning how students formed science attitudes. Learning how to optimize both commitment to science and achievement in science among students in schools were the goals of such research. (Talton and Simpson, 1986)

This need has been expressed throughout science education literature to study the relationships among variables having potential impact on students' science attitudes and achievement. It has been suggested that attitudes should be studied in relation to multiple variables. When research findings regarding the impact of favorable attitudes on differences in science achievement were reported, positive significant relationships between science achievement and attitudes toward science were found. In a national study on science education research, it was found that investigations seeking relationships between student variables were priority areas. (Harty, Beall, and Scharmann, 1985)

The concern with development of student attitudes in science came from two major ideas. First, since science had an important place in affecting society and will mold future ones, science education was considered to be a basic ingredient of general education needed

by all people in today's world. Second, science instruction should enhance student attitudes and guide many students to select a science career to meet employment demands developed by technological growth. (Hasan, 1975)

Both popular and scientific publications have stated that United States citizens were less knowledgeable about and less attuned to science than in the past. Shortages of personnel in areas of science, mathematics, and engineering have appeared, and the level of scientific literacy of the general populace has declined. Science educators believed that if this trend was not soon reversed, the United States would no longer be a world leader in science and technology. (Simpson and Troost, 1982)

## STATEMENT OF THE PROBLEM AND PURPOSE OF THE STUDY

Science educators were interested not only in students' cognitive achievement, but also in the positive development of students' attitudes toward science. Lawrenz (1975) stated that since two important outcomes of science education are increased achievement, and improved student science attitudes, the criteria for successful teaching should be these outcomes. Gardner (1976) stressed that because students made important decisions, such as subject and career choices based on their attitudes, research on attitudes was a very important area. However, there were many variables which affected students' attitudes toward science.

This study was conducted to identify the variables which may affect students' attitudes toward science, and to describe the extent to which

the variables affect attitudes. The variable identified in this paper could be manipulated by educators to create a classroom environment that promotes the growth of more positive attitudes toward science.

## ORGANIZATION OF THE STUDY

The research material was divided into four major categories based on four definitions of attitudes toward science. The articles were divided into categories according to the main idea presented.

In the first part of the study, attitudes toward scientific interests were examined. Scientific interests referred to those interests that students have in common with scientists. (Haladyna and Shaughnessy, 1982)

The second major category reviewed attitudes as an approach to thinking about science. In this section, attitudes toward science were defined as cognitive attitudes, or as a belief about thinking. (Haladyna and Shaughnessy, 1982)

The third major category dealt with attitudes toward the subject matter of science. These were attitudes that were direct outcomes of schooling. (Haladyna and Shaughnessy, 1982) This category was further subdivided into two sections: multiple variable research and research on learning environment variables.

In the final section, attitudes as affected by teaching method were examined. These were attitudes affected by specific instructional activities. (Haladyna and Shaughnessy, 1982)

The annotations were arranged in chronological order within each

major category or subdivision. The four categories were arranged within the paper according to the logical development of the study.

## LIMITATION OF THE STUDY

There were many research articles on variables which affect students' attitudes. However, a time deadline limited an investigation into all of the related data.

## DEFINITION OF TERMS

attitudes toward science -- (1) "a students approach to thinking about science."; (2) "attitudes of students toward specific instructional activities or methods."; (3) "interests in common with scientists."; (4) "student attitudes as an important outcome of schooling." (Haladyna and Shaughnessy, 1982: 548-549)

attitudinal dimension -- "...the expressed attitudes, ambitions, and aspirations of a principal actor." (Keeves, 1975: 441)

commitment to science -- "includes the interests, attitudes, values, and other affective behaviors of students." (Simpson and Troost, 1982: 765)

content variables -- "describe one of three constructs: (a) student, (b) teacher, and (c) learning environment." (Haladyna, Olsen, and Shaughnessy, 1982: 672)

control behavior -- "the need to establish and maintain a satisfactory relationship with people with respect to power and authority." (Schafer and Vargo, 1976: 3)

cultural variables -- "educational levels of the family." (Hasan, 1975: 260)

emotional attitudes -- "based on a feeling or emotional reaction to the psychological object of the attitude." (Ward, 1976: 137)

endogenous variables -- "those that are under the influence of the schooling process and may have a direct or indirect influence on attitude toward the subject matter of science." (Haladyna, Olsen, and Shaughnessy, 1982: 673)

environmental attitudes -- "student attitudes in the study of the environment." (Moyer, 1975: 266)

exogenous variables -- "located outside the institution of schooling and are not under the direct influence of the schooling process." (Haladyna, Olsen, and Shaughnessy, 1982: 673)

fatalism -- "the students' perceived ability to affect their own success at school." (Haladyna, Olsen, and Shaughnessy, 1983: 312)

focus -- "refers to another dimension of variables: exogenous and endogenous." (Haladyna, Olsen, and Shaughnessy, 1982: 673)

formality scale -- "represents a strict, teacher-controlled classroom environment." (Lawrenz, 1975: 436)

inner motivational variables -- "career desired by student, perception of science abilities." (Hasan, 1975: 259)

instructional variables -- "motivation of teacher, motivation of science textbook, participation in extra-curricular science activities." (Hasan, 1975: 259)

intellectual attitude -- "based on some knowledge about the psychological object of the attitude." (Ward, 1976: 137)

interests in science -- "patterns of choice among alternative patterns that demonstrate some stability over time and do not appear to result from external pressures." (Harty, Anderson, and Enochs, 1984: 309)

learning environment variables -- "are descriptive of the context and setting of the instructional program." (Haladyna, Olsen, and Shaughnessy, 1982: 672)

mastery learning strategy -- "consists essentially of frequent diagnosis and remediation of learning difficulties prior to summative testing." (Dillashaw and Okey, 1981: 1)

needs -- "motivational personality characteristics, representing tendencies to move in the direction of certain goals." (Gardner, 1976: 113)

originator compatibility -- "refers to the extent to which there is agreement as to who should originate or initiate an interpersonal exchange." (Schafer and Vargo, 1976: 6)

outer motivational variables -- "motivation of parents, career desired by parents, social desirability of science." (Hasan, 1975: 259)

press -- "environmental influences which support and encourage the expression of needs." (Gardner, 1976: 113)

process dimension -- "...the things done by parents, teachers, and friends to which the child attends or reacts and which influence the child's educational performance." (Keeves, 1975: 441)

pupil personality characteristics -- "achievement, conjunctivity, deference, play, understanding, order, nurturance, energy." (Gardner, 1976: 113)

reactive curiosity -- "(1) a tendency to approach and explore relatively new stimulus situations; (2) a tendency to approach and explore incongruous, complex stimuli, and (3) a tendency to vary stimulation in the presence of frequently experienced stimulation." (Harty, Anderson, and Enochs, 1984: 309)

reciprocal compatibility -- "refers to the extent to which the expressed behavior of one individual is equal to the wanted behavior of the other, and vice versa." (Schafer and Vargo, 1976: 6)

school variables -- "school types, future specialization, curriculum." (Novick and Duvdvani, 1976: 259)

structural dimension of the home -- "...occupational status, educational level, income of head of household, and size of family." (Keeves, 1975: 441)

structural dimension of the school -- "...school type, class size, school size, and expenditure per student." (Keeves, 1975: 441)

student variables -- "involve any indicators which are attributable to the individual student and are not part of a larger context." (Haladyna, Olsen, and Shaughnessy, 1982: 672)

teacher characteristics -- "...competitiveness, organization, compliance, pleasure, intellectualization, compulsiveness, warmth, stimulation." (Gardner, 1975: 113)

teacher variables -- "indicators that are unique to the individual science teacher." (Haladyna, Olsen, and Shaughnessy, 1982: 672)

ANNOTATIONS

ATTITUDES TOWARD SCIENTIFIC INTERESTS

Hasan, Omar E., "An Investigation into Factors Affecting Science Interests of Secondary School Students," Journal of Research in Science Teaching 12(3):255-261, July, 1975.

Three hundred forty eleventh grade science students were the subjects of a study designed to determine the influence of selected variables on the development of student interest in science. There were four groups of variables tested: instructional, cultural, outer motivational, and inner motivational. Student interest in science was measured by a science interest scale administered to students at the beginning of the 1971 school year. Upon analysis of the data, Hasan concluded that some of the variables tested did differentiate between high and low science interest students. The author found that none of the cultural variables differentiated significantly between high and low science interest students.

Lazarowitz, Reuven; and Others, "Reasons Why Elementary and Secondary Students Do and Do Not Like Science," Educational Resources Information Center, Ed 214 797, Utah State Board of Education, April 14, 1981, 21 pages.

Approximately two thousand students from grades six through twelve were the subjects of a study that had two purposes: (1) to find out why elementary and secondary students like science, and (2) to see if there were any differences in the reasons why students like science subjects according to type of school, age, and sex. Data were collected by administering a questionnaire that asked students to list five science subjects they were interested in, to choose reasons from a list as to why they were interested in a science subject, to list a science subject they did not like, and to give a reason for the dislike. Upon analysis of the data, it was shown that the reason chosen most for liking a science subject was liking to go outdoors. The second most chosen reason was liking to see things live and grow. The reason given most for disliking a science subject was related to a teacher's way of teaching and the teacher as a person.

## ATTITUDE AS AN APPROACH TO THINKING ABOUT SCIENCE

Moore, Richard W., "A Profile of the Scientific Attitudes of Six Hundred Seventy Two Ninth-Grade Students," School Science and Mathematics 71:229-232, March, 1971.

Six hundred seventy two ninth-grade students were the subjects of a study designed to present a profile of the scientific attitudes of the students as measured by the Scientific Attitude Inventory (SAI). The SAI was administered to the students in the Spring of 1969 to gather information showing how ninth-grade students would respond. From analysis of the data, Moore made four conclusions: (1) Students did not strongly accept positive science attitudes or strongly reject negative scientific attitudes; (2) The lack of strong attitudes to science is demonstrated by the small differences between positive scales and corresponding negative scales; (3) Students lack an understanding of the differences between science and technology; (4) Students do not understand the nature of scientific explanations given as laws and theories. The author further stressed that if the group tested was typical of most ninth-grade students in the United States, development of scientific attitudes needed more attention.

Moyer, Richard H., "An Investigation of Factors Influencing Environmental Attitudes," School Science and Mathematics 75:266-269, March, 1975.

In order to investigate possible factors in the formation of environmental attitudes, environmental attitudes and knowledge were measured by the Syracuse Environmental Awareness Tests, forms A and D. Form A was a multiple choice cognitive test and form D was a forced-choice affective test. Two hundred twenty four high school seniors were administered the cognitive test and two hundred forty one the affective test. The students' scores on both the affective and cognitive tests were correlated with student grades in all courses. Also examined was the correlation between each student's overall grade point average and socio-economic status. Significant correlations were found between affective and cognitive test scores, cognitive test scores and students' grade point averages, cognitive test scores and socio-economic status as determined by the father's occupation, and cognitive test scores and grades in electricity, astronomy, geology, biology, history, science, and social studies. Electricity, biology, and individualized reading showed a significant correlation between grades and affective test results. Overall grade point averages in science, social studies, and home arts also showed significant correlations with affective test scores. No significant correlation was found between students' attitudes toward the environment and their overall grade point averages. From the data, Moyer concluded that wherever students were forming their attitudes toward the environment, they were not being influenced to any great extent in the classroom. The writer also concluded that this study did not satisfactorily answer the question, what are the factors that relate to environmental attitudes. The author recommended further research on variables other than those investigated in this study.

Novick, Shimson, and Duvdvani, Dina, "The Relationship between School and Student Variables and the Attitudes toward Science of Tenth-Grade Students in Israel, "Journal of Research in Science Teaching 13:259-265, May, 1976.

Six hundred eighty four Israeli tenth-grade students from twenty five schools were the subjects of a study attempting to assess the relative level of general scientific attitudes of these students, and designed to examine the effects of certain variables on student attitudes. The variables were divided into two types: school variables and student variables. School variables were school types, future specialization, and curriculum. Student variables were sex, achievement level, and cultural background. The Scientific Attitude Inventory was chosen to measure intellectual and emotional attitudes to science. The students were tested in the 1973 school year. Upon analysis of the data, the authors concluded that five of the six variables significantly affected students' attitudes to science. Curriculum was the only variable that appeared not to affect student attitude.

Simpson, Ronald D., and Troost, Michael Kay, "Influences on Commitment to and Learning of Science among Adolescent Students," Science Education 66(5):763-781, October, 1982.

Four thousand five hundred sixth through tenth grade science students from twelve schools located in central North Carolina were the subjects of a study to measure achievement in science and commitment to science among adolescents as affected by school, individual, and family factors. Commitment to science was defined as the values, interests, and attitudes of science students. The researchers developed their own attitude questionnaires and criterion-referenced achievement tests for the study. Analysis of the first year's data showed that home commitment to science was a strong positive correlate to the student's commitment to science.

Harty, Harold; Anderson, Hans O.; and Enochs, Larry G., "Exploring Relationships among Elementary School Students' Interests in Science, Attitudes toward Science, and Reactive Curiosity," School Science and Mathematics 84:308-315, April, 1984.

Ninety one fifth-grade science students were the subjects of a study designed to determine if statistical relationships existed between three conceptually related affective variables: interest in science, attitudes toward science, and reactive curiosity. Interest was measured by the administration of the "Children's Interest in Science Measurement". Attitudes were measured by the administration of the "Children's Attitude toward Science Survey". Curiosity was measured by a shortened version of the "Children's Reactive Curiosity Scale". When the data were analyzed, significant positive correlations were found between attitudes toward science and curiosity, between interest in science and curiosity, and between interest in science and attitudes toward science. Further study of the data showed high average scores for activity-oriented items; lower average scores appeared for items that involved passive actions. The authors suggested that students more interested in science and those less interested in science both preferred highly active involvement.

Harty, Harold; Beall, Dwight; and Scharmann, Lawrence, "Relationships between Elementary School Students' Science Achievement and Their Attitudes Toward Science, Interest in Science, Reactive Curiosity, and Scholastic Aptitude," School Science and Mathematics 85(6): 472-479, October, 1985.

The subjects were two hundred ninety three fifth-grade students. Student achievement was measured by the "Iowa Tests of Basic Skills - Science Supplement". Pupils' attitudes toward science were measured by the "Children's Attitudes Toward Science Survey". The students' interests in science were tested by the "Children's Interests in Science Measure". Curiosity was measured by the "Children's Reactive Curiosity Scale". Pupil scholastic aptitude was determined through the use of the "Cognitive Abilities Test: Multi-level Form 3". Data were collected during a three-week period. The data revealed that a potential relationship existed between the criterion variable of science achievement and the predictor variables of attitudes toward science, interest in science, reactive curiosity, and scholastic aptitude. Positive significant correlations were found between achievement in science and all predictor variables. The researchers concluded that teachers can influence the positive development of science cognitive achievement, scholastic aptitude, and attitudinal tendencies in the classrooms; that classroom interactions that stressed the relationship of cognitive development to attitudes, interest and curiosity were needed.

## ATTITUDES TOWARD THE SUBJECT MATTER OF SCIENCE

### Multiple Variable Research

Wick, J.W., and Yager, R.E., "Some Aspects of the Students' Attitudes in Science Courses," School Science and Mathematics 66:269-273, March, 1966.

Junior and senior high school science classes were the subjects of a study designed to measure the attitudes of students. Data was gathered by administration of the "Scale to Measure Attitude Towards Any School Subject". After analysis of the data, the researchers made four conclusions: (1) A portion of any group of students showed a marked decrease in course attitude. There was not a similar group that showed a matched gain in attitude. (2) Attitude toward the classroom teacher was a very important factor in determining attitudes toward the course. (3) Grades were not an important factor in determining attitudes toward the course. (4) Students' attitudes toward science courses tended to change over a period of time.

Keeves, J.P., "The Home, the School, and Achievement in Mathematics and Science," Science Education 59(4):439-460, October-December, 1975.

Two hundred fifteen students entering the seventh grade were the subjects of a study designed to examine the manner in which traits of the educational environment of the home, the school, and the peer group were related to changes in performance at school over the period of a year. The subjects were tested at the beginning and at the end of the school year. The author identified three dimensions of educational environments for the home, school, and peer group: the structural dimension, the attitudinal dimension, and the process dimension. Upon analysis of the data, Keeves found causal connections between achievement and attitude to science, and the educational environment of the home, the classroom, and the peer group. Initial achievement in science, and attitude and practices of the home were factors that influenced achievement in science. Structural characteristics of the classroom, and interactions between the teacher and the student also exerted an influence. The author also found that achievement in science made a large contribution to attitudes of liking science at the end of the year. Also discovered to have an important influence were gender of the student, participation by the student's friends in science activities, and interactions between the teacher and student.

Gardner, P.L., "Attitudes toward Physics: Personal and Environmental Influences," Journal of Research in Science Teaching 13(2): 111-125, March, 1976.

A total of one thousand fourteen science students in fifty eight classes under forty different teachers in thirty four schools were the subjects of a study attempting to measure the attitudes of students toward various parts of a high school physics course, and to relate these attitudes to pupil personality and teacher characteristics. Four attitudes toward physics were measured by the Physics Attitude Index (PAI): views toward physics learning, beliefs about physics as a process, views toward scientists, and enjoyment of physics. Needs were measured by the Personal Preference Index (PPI), and press was measured by the Physics Classroom Index (PCI). Motivational personality characteristics, representing tendencies to move toward certain goals are referred to as needs; environmental influences that support and encourage the expression of needs are referred to as press. The PAI was administered at the beginning of the eleventh-grade year and again at the end of the year. The PCI and the PPI were administered in a single class period in the middle of the year. After analysis of the data, Gardner concluded that the major finding of the study was a large decline in enjoyment of physics shown by most students. All students did not display a decline in enjoyment. Intellectual, achievement-motivated students with intellectual, achievement-pressing teachers kept a high level of enjoyment. Other students with other types of teachers showed a decline. The writer found that competitiveness and achievement were the most significant teacher and pupil characteristics. High achievement-oriented pupils tended to best maintain a positive attitude when paired with teachers who scored high on competitiveness. Low achievement-oriented pupils did best in an atmosphere of low competitiveness. The author further concluded that teacher and student effects can be very powerful - greater than the effects caused by different instructional materials.

Schafer, Larry E., and Vargo, Robert A., "Student Science Attitudes and Self-Concepts in Science as a Function of Role Specific Pupil/Teacher Interpersonal Compatibility," Educational Resources Information Center, Ed 129 592, n. pub., April, 1976, 27 pages.

Seven ninth-grade science teachers and their three hundred thirty four students were the subjects of a study designed to predict students' self-concepts in science and science attitudes by the use of a role-specific measure of pupil-teacher compatibility and a measure of students' perceptions of compatibility. Attitude, interpersonal compatibility, and self-concept instruments were administered to the subjects. From analysis of the data, a significant positive correlation was found between attitude toward science and sex of the student. Female students were associated with more negative attitudes toward science than were male students. Student perceived originator control compatibility and reciprocal control compatibility showed significant positive correlations with self-concept in science. Originator control compatibility was also found to be significantly and positively correlated with student attitude. The authors concluded that differences in the wanted and expressed control behaviors of teachers and students must be resolved and dealt with in order to maintain a suitable learning atmosphere.

Haladyna, Tom; Olsen, Robert; and Shaughnessy, Joan, "Relations of Student, Teacher, and Learning Environment Variables to Attitudes Toward Science," Science Education 66(5):671-687, October, 1982.

Six hundred forty nine fourth-grade students, six hundred thirty seventh-grade students, and six hundred eighty six ninth-grade students were the subjects of a study intended to measure the relationships of student, teacher, and learning environment variables to attitudes toward the subject matter of science. The authors identified two dimensions of variables: content and focus. In order to measure the relationship of these variables to science attitudes, the Inventory of Affective Aspects of Schooling was administered to the subjects on three grade levels by a test administrator. The teachers left the room and completed a teacher questionnaire. Upon analysis of the data, the researchers made four conclusions. (1) No evidence was found to prove that meaningful relationships existed between exogenous student variables and science attitudes. (2) The students' sense of importance of science and their level of fatalism were shown to be strongly related to student attitudes toward science. Self-confidence was also shown to be strongly related. (3) The data revealed a high relationship of endogenous teacher enthusiasm, respect for the teacher's knowledge, teacher's support of students, and teacher praise. (4) Learning environment was found to be highly related to attitudes toward science. It was seen that students must have satisfaction with the work they do, the class environment must be positive, and instruction needed to be organized.

Haladyna, Tom; Olsen, Robert; and Shaughnessy, Joan, "Correlates of Class Attitude Toward Science," Journal of Research in Science Teaching 20(4):311-324, April, 1983.

Science students in grades four, seven,and nine participated in a study designed to investigate the relationships of many variables to attitudes toward the school subject of science. Data was collected by administration of the Inventory of Affective Aspects of Schooling to the students. A questionnaire was administered to the teachers. In the fourth grade, gender was significantly correlated to science attitude; girl-dominated classes were more inclined to like science. The importance of science was found to be very highly related to attitudes toward science. A moderate correlation was found between fatalism and attitude. Also, the number of lower division science courses completed by the teacher was positively associated with class attitudes toward science. The author suggested that perhaps better prepared teachers tended to create a more positive attitude in their students. In grade seven, only three endogenous student variables were found to be significant: importance of science, fatalism, and self-confidence. No exogenous student variables were found to be significant. Teacher quality variables were found to have a very high positive correlation with attitude. Professional involvement variables were also highly related to science attitude. Of the learning environment variables, those in the management-organization category were positively significant. In the ninth grade, a new positive factor that emerged was parental involvement. The endogenous student variables of importance of subject matter and fatalism were once again highly related to science attitude. Correlations between teacher variables such as enthusiasm and overall teacher quality and attitude were relatively high. Of the learning environment variables tested, strong relationships with attitude were discovered in such variables as diversity, attentiveness, and satisfaction. Variables found to be consistently related to science attitude at all grade levels were the sense of importance of science, student fatalism, teacher quality, and many learning environment variables.

Talton, Lynn E., and Simpson, Ronald D., "Relationships of Attitudes Toward Self, Family, and School with Attitudes Toward Science Among Adolescents," Science Education 70(4):365-374, July, 1986.

This study was part of a large, longitudinal, multidimensional study designed to examine attitudes of adolescent science students from grades six through ten. A large and socially diverse school system from central North Carolina was selected for the study. The county was divided into four quadrants, and a stratified random sampling plan was used to select twelve of the fifty five schools in the system. Each quadrant was represented by one elementary school, one junior high school, and one high school. The test used in this study was developed to measure the attitudes of adolescents toward science. Testing was done over the period of one year. The data revealed that of the three sets of variables, the classroom environment variables proved to be the best predictor of attitudes toward science at all grade levels. The researchers concluded that the three categories of variables (self, family, and classroom environment) all contained significant predictors of attitudes toward science. They suggested that a large portion of the variance in attitudes toward science may be explained by students' feelings about self, family, and the classroom environment. They also indicated that all three categories of variables have a positive relationship with attitudes toward science.

Learning Environment Variables

Lawrenz, Frances, "The Relationship between Science Teacher Characteristics and Student Achievement and Attitude," Journal of Research in Science Teaching 12:433-437, October, 1975.

Two hundred thirty six secondary science teachers (eighty four biology teachers, one hundred eleven chemistry teachers, and forty one physics teachers) were the subjects of a study to determine if a relationship existed between selected teacher characteristics and student achievement and attitude, and to provide some indication of the relative importance of the teacher characteristics. Five teacher characteristics were selected: knowledge of subject matter and teaching methods, experience, attitude toward science, professional self-improvement, and type of learning environment created. Each science teacher completed a questionnaire, the National Teachers' Exam in Science, the Science Process Inventory (SPI), and the Science Attitude Inventory (SAI). Each teacher selected one of his own classes to complete the SPI, the SAI, the Learning Environment Inventory (LEI), and the Test on Achievement in Science (TAS). The criteria for determining teacher effectiveness were student achievement and attitude. The SPI and the TAS measured student achievement. The SAI measured student attitude. Information on the teacher characteristics was gathered from scores on the tests they took and from a questionnaire. Analysis of the teacher data yielded four characteristics that were highly related to student variables: the LEI scales of Formality, Goal Direction, and Self-Improvement, and the SPI score. Lawrenz concluded from the data that a relationship between selected teacher characteristics and student achievement and attitudes did exist. The author stressed that teacher educators should be concerned with the development of these characteristics. The four characteristics that ranked highest were formality, self-improvement, knowledge of science processes, and goal direction. Formality was negatively correlated, and self-improvement, knowledge of science processes, and goal direction were positively correlated.

Ward, W.H., "A Test of the Association of Class Size to Students' Attitudes toward Science," Journal of Research in Science Teaching 13:137-143, March, 1976.

High school biology, chemistry, and physics classes from twelve states in three regions of the United States were the subjects of a study to determine if a class size-student attitude relationship did exist among the subjects. For the study, attitude was defined in two segments: an intellectual attitude based on knowledge about the psychological object of the attitude, and an emotional attitude based on a feeling toward the psychological object of the attitude. Eight variables were selected for use in the study: class size, student attitude toward science, student achievement in science, teacher attitude toward science, student emotional attitude toward science, teacher emotional attitude toward science, student intellectual attitude toward science, and teacher intellectual attitude toward science. Data was collected on these variables by the administration of the Science Attitude Inventory and the Test of Achievement in Science. Three analyses were performed on the data: one on only emotional attitudes, one on only intellectual attitudes, and one as the sum of both components. After analysis of the data, Ward made three conclusions: (1) No evidence was found to support the idea that positive attitudes toward science were associated with smaller class size at the high school level; (2) Total Attitude was not divisable into Emotional Attitude and Intellectual Attitude; (3) Class Size-Achievement and Achievement-Attitude did produce significant correlations on the emotional, intellectual, and composite modes. The writer further concluded that there was little evidence for theories that proposed affective reactions of students to subject areas are related to instructional unit size. The author warned, however, that a chain from unit size to achievement to attitude may exist. Ward stressed that a small association of class size to achievement did exist in the data collected, and that the strong association between achievement and attitudes should not be ignored.

Lawrenz, Frances, "The Prediction of Student Attitudes toward Science from Student Perception of the Classroom Learning Environment," Journal of Research in Science Teaching 13(6):509-515, November, 1976.

Two hundred thirty eight high school classes participated in a study designed to produce information on how well biology, chemistry, and physics students' attitudes toward science could be predicted from their perceptions of the classroom learning environment. Two instruments, the Learning Environment Inventory and the Science Attitude Inventory, were completed by classes chosen at random by one biology, chemistry, or physics teacher at each participating school. The data collected was grouped by subject matter. From analysis of the data, the author made several conclusions: Favoritism appeared to be the best predictor of biology students' attitudes toward science; Friction appeared to be the best predictor for chemistry students' attitudes toward science; none of the indicators were significant for physics classes; social climate of the classroom was a poor predictor of attitudes toward science for physics classes. The hypothesis that student perception of the learning environment may have been related to student attitude toward science was supported for biology and chemistry students, but not for physics students. The investigator recommended in further discussion of the data that chemistry and physics teachers should make their classes challenging because students in these classes seemed to enjoy the challenge of a difficult class. At the same time, biology teachers should take care that their students do not develop a negative attitude induced by material presented in too difficult a manner. Lawrenz also pointed out that Friction and Favoritism were negative predictors for all classes. This result showed that students work best in an atmosphere that is cooperative rather than competitive. The author stressed that these factors are important because they are variables that can be manipulated to help produce positive attitudes.

Fraser, Barry J., "Environmental Factors Affecting Attitude toward Different Sources of Scientific Information, Journal of Research in Science Teaching 15:491-497, November, 1978.

Five hundred thirty one seventh-grade science students in twenty different classes, each in a different coeducational government high school, were the subjects of a study designed to explore the relationship between a set of science-related attitudinal outcomes and student perceptions of the classroom learning environment. The attitudinal outcomes studied were student attitudes toward four sources of scientific information: conducting an experiment, consulting an expert, reading a book, and asking a teacher. The learning environment variables were a set of nine sociopsychological dimensions: Diversity, Speed, Environment, Goal Directions, Satisfaction, Disorganization, Difficulty, Competitiveness, and Individualization. Student characteristics of socioeconomic status, general ability, and gender were statistically controlled. Student learning environment perceptions were measured by a version of the Learning Environment Instrument modified for use in junior high school science classrooms. Attitudinal outcomes were measured by the Test of Interests. Attitudes were measured at the beginning of the year and at the end of the year. Other variables were measured at midyear. After analysis of the data, Fraser concluded that the idea that learning environment perceptions have predictive validity in accounting for variance in learning outcomes was supported by the data. The author also noted an interesting pattern of relationships between individual learning environment variables and attitudes toward different sources of scientific information. Fraser found that more favorable learning environments created more positive attitudes toward experiments as a source of information; less favorable learning environments created more positive attitudes toward experts, books, and teachers. A less favorable environment was defined as being more difficult, more competitive, more disorganized, and having fewer resources available.

Fraser, Barry J., and Butts, William L., "Relationship Between Perceived Levels of Classroom Individualization and Science-Related Attitudes," Journal of Research in Science Teaching 19(2):143-154, February, 1982.

Seven hundred twelve seventh, eighth, and ninth grade students were the subjects of a study that measured student attitudes toward science and perceived levels of classroom individualization. The results were then analyzed to find relationships that existed between perceived classroom individualization and students' attitudes toward the subject matter of science. It was discovered that Social Implications of Science scores were greater in classrooms perceived as having greater Personalization, Participation, and Independence; and high Leisure Interest in Science scores and Career Interest in Science scores were found in classes perceived as having greater Participation. In each of the cases, perceptions of greater individualization were associated with more positive attitudes.

Okebukola, Peter Akinsola, "An Investigation of Some Factors Affecting Students' Attitudes toward Laboratory Chemistry," Journal of Chemical Education 63(6):531-532, June, 1986.

One thousand six hundred thirty eight eleventh-grade chemistry students were the subjects of an investigation designed to examine a number of factors which affect students' attitudes toward chemistry laboratory work. The students were enrolled in seventy eight secondary schools drawn from rural, suburban, and urban areas of Oyo State, Nigeria. Data were gathered by means of the "Attitudes Toward Chemistry Laboratory Work Scale" and the "Students' Attitudes to Chemistry Questionnaire". Data collections in each school lasted for two weeks. When the data were ranked, it was revealed that students' attitudes toward chemistry as a subject and students' participation in laboratory activities are the first and second factors in their effect on students' opinions of laboratory chemistry. It also revealed that students' attitudes toward chemistry as a subject were most strongly correlated with positive attitude toward the laboratory followed by students' participation in laboratory activities. Time allotted to laboratory activities was found to be a strong correlate of students' positive attitudes toward the laboratory. Okebukola concluded that the attitude of the student towards chemistry as a subject was the most important determinant of the attitude toward the laboratory. Students' participation in laboratory activities was the second most important factor. The author suggested that a greater degree of participation in laboratory work may produce more positive attitudes toward the laboratory.

ATTITUDE AS AFFECTED BY TEACHING METHOD

Lowery, Lawrence F., "An Experimental Investigation into the Attitudes of Fifth Grade Students toward Science," School Science and Mathematics 67:569-579, June, 1967.

Three hundred thirty five children from twelve fifth-grade classes were the subjects of a study that measured the students' attitudes toward science as influenced by a new curriculum material, the Animal Coloration Unit. It was developed by the Elementary School Science Project at the University of California. Classes were selected from three socioeconomic areas designated as upper, middle, and lower. Income, employment, and educational factors formed the basis for selection. Within each area, classes were paired on the basis of IQ mean scores. The selection method resulted in two experimental and two control classes in each socioeconomic area. The experimental groups were taught the new science unit on animal coloration. The control groups were taught a science unit of similar length on the topic of animals from the California state textbook series. Fourteen to fifteen lessons were taught to both the experimental and control classes. Measures of attitudes in all groups were obtained before and after experiencing the unit by using the Projective Tests of Attitudes. When the data were analyzed, Lowery concluded that fifth-grade children who were taught the new Animal Coloration Unit changed their attitudes toward science in a positive way that was significantly greater than the changes made by similar children who were not taught the new material.

Starr, Robert J., "A Study of the Use of 'Invitations to Enquiry' and Student Attitude," Journal of Research in Science Teaching 9:247-251, n. month, 1972.

One hundred thirty two high-ability ninth-grade Biological Science Curriculum Study (BSCS) students were the subjects of a study designed to isolate the attitudes of such students toward instruction utilizing "Invitations to Enquiry". "Invitations to Enquiry" claimed to challenge and reward students as they participated in solving problems. This challenge and reward should have resulted in more positive student attitudes. The study tested these claims by measuring student attitudes before, during, and after the use of "Invitations to Enquiry". Both control and experimental were instructed in a similar manner with twenty "Invitations to Enquiry" added to the experimental classes over an eight week period. Starr found no statistically significant differences in attitudinal scores as measured by Remmer's A Scale to Measure Attitude Toward Any School Subject. However, Starr did find an insignificant increase in experimental class mean scores from midstudy to post-test. The author suggested that the more difficult later "Invitations" actually contributed to the development of more positive attitudes toward biology. The researcher hypothesized that a significant change in interest and attitude might occur if the "Invitations" were added to a more traditional biology course instead of BSCS. Starr also pointed out that this study concentrated on high-ability students, and recommended further study to see if lower-ability students might find the material stimulating too.

Kempa, R.F., and Dubé, G.E., "Science Interest and Attitude Traits in Students Subsequent to the Study of Chemistry at the Ordinary Level of the General Certificate of Education," Journal of Research in Science Teaching 11(4):361-370, n. month, 1974.

In 1966, G.R. Meyer performed a study designed to measure students' reactions to the new Nuffield Science Teaching Project materials developed in English Ordinary Level courses in biology, chemistry, and physics. Meyer found the Nuffield O-level chemistry course to be very effective in promoting positive changes in variables such as general interest in science and attitude to science teaching at school level. Since then, non-Nuffield science syllabuses have undergone revision. Therefore, Kempa and Dubé undertook a study to examine student interest and attitude traits in present day Nuffield and non-Nuffield students, and to compare them with those discovered by Meyer.

Two hundred eighty four eleventh-grade students were the subjects of a study to determine affective characteristics in students following O-level chemistry courses, both Nuffield and non-Nuffield. The subjects were divided into an experimental group (Nuffield) and a control group (non-Nuffield). The subjects were tested using Meyer's Test of Interests. The researchers proposed three conclusions upon analysis of the data: (1) Present day non-Nuffield courses promoted positive science interest and attitude traits more strongly than the Nuffield O-level chemistry course. This was a complete reversal from Meyer's findings in 1966. The authors proposed that this could be explained by the better balance in revised non-Nuffield courses between "problem-centered" and "fact-centered" course content; (2) Analysis of achievement scores showed a strong positive relationship between attitude measures and academic achievement for both Nuffield and non-Nuffield students; (3) Students who are academically weak and not fully capable of understanding the conceptual content in chemistry courses, still derived satisfaction from learning its factual content. Some factual content should be included in a chemistry course for lower ability students.

LaSheir, W.S., and Nieft, J.W., "The Effects of an Individualized, Self-Paced Science Program on Selected Teacher, Classroom, and Student Variables-ISCS Level One," Journal of Research in Science Teaching 12:359-369, October, 1975.

Approximately eleven hundred seventh-grade students were the subjects of a study that had two main purposes: (1) to look for relationships and differences in the answers of pupils in Intermediate Sciences Curriculum Study (ISCS) classes and pupils in non-ISCS classes as assessed by the Student Inventory (WDM) and the Classroom Activity Checklist (CAC); (2) to find differences that may have existed between high and low achievers in ISCS classes as assessed by the Scientific Attitude Inventory (SAI), the CAC, and the WDM. Data was gathered from two groups over a two year period. The students in the experimental group received science instruction using the ISCS curriculum. The students in the control group received science instruction via a method that stressed laboratory-centered science activities but did not use ISCS. Upon analysis of the data, the authors made several conclusions. There were no significant relationships found between students' cognitive achievement progress in ISCS and perception of classroom activity, students' experiences in ISCS classrooms, or non-ISCS classrooms and student perception of teacher personality traits, and teacher traits such as warmth and demand and students' cognitive achievements in ISCS. A significant relationship was found between the change in student perception of classroom activity in non-ISCS classrooms and ISCS classrooms. Also, a significant positive relationship was seen between student attitude and cognitive achievement progress in ISCS. High-achieving ISCS students showed higher scores on attitude measures than low-achieving ISCS students.

Vanek, Eugenia Poporad, and Montean, John J., "The Effect of Two Science Programs (ESS and Laidlaw) on Student Classification Skills, Science Achievement, and Attitudes," Journal of Research in Science Teaching 14(1):57-62, January, 1977.

Fifty four students from two third-grade classrooms and fifty six students from two fourth-grade classrooms were the subjects of a study to compare the effects on student classification skills, science achievement, and scientific attitudes of various units in a textbook approach (Laidlaw Science Series) to an activity-based curriculum (Elementary Science Study). Students were assigned to one of two treatment groups at each grade level. One group was an ESS treatment group and the other was a textbook-oriented group. The study was conducted over a six to eight week period for twenty class sessions of forty minutes each. Results were measured by the Piagetian Classification Tasks, the Science Attitude Scale, and the Science Achievement Test. From analysis of the data, the researchers concluded that teaching method or materials did not make a significant difference in the classification ability, science achievement, or attitudes of these third and fourth-grade students. They also concluded that the hypothesis that ESS classrooms differ from textbook-oriented classrooms was not supported. They stressed, however, that the data showed that teachers using an activity-oriented approach seemed to be just as effective as teachers using a textbook approach.

Knight, Carlton W., and Dunkleberger, Gary E., "The Influence of Computer-Managed Self-Paced Instruction on Science Attitudes of Students," Journal of Research in Science Teaching 14:551-555, November, 1977.

Ninety four ninth-grade students enrolled in an Introduction to Chemistry and Physics (ICP) course at a Delaware suburban high school were the subjects of a study designed to measure the effects of computer-managed self-paced instruction on student attitudes toward the subject of science. Forty six students were assigned to a group which participated in computer-managed self-paced (CMSP) laboratory instruction. CMSP instruction allowed immediate feedback via a computer screen on questions that assessed attainment of the concepts presented in the laboratory. Forty eight students were assigned to a group which participated in teacher-managed group-paced (TMGP) laboratory instruction. In the TMGP group, assessment of the attainment of concepts was gained by teacher evaluation of student-developed laboratory reports. The students were assigned to these groups for a full academic year. A modified version of the Student Opinion Survey of Chemistry was administered to the students at the beginning of the year, the end of the first semester, and at the end of the academic year. Four dimensions of student attitude were measured: (1) favorable attitudes toward science courses in general, (2) future educational plans, (3) distaste for science as a subject, and (4) a specific distaste for the present science course. When the data were analyzed, students in the CMSP group showed significantly more positive overall attitudes toward the study of science than did the students in the TMGP group. The researchers concluded that CMSP instruction did improve student attitudes toward the study of science.

Sabar, Naama, and Kaplan, Eugene H., "The Effect of a New Seventh-Grade Biology Curriculum on the Achievements and Attitudes of Intellectually and Culturally Heterogenous Classes," Journal of Research in Science Teaching 15(4):271-276, July, 1978.

Experimental classes in one school and control classes in four schools participated in a study designed to evaluate a new teaching-learning model. The new model was examined to see if it significantly improved the affective and achievement performance functions in the disadvantaged segment of a culturally and intellectually heterogenous class, while maintaining the performance levels and attitudes of the average and above-average student. The model consisted of five parts: (1) a lecture/discussion followed by a story and a concept list, (2) a laboratory experience using the same concepts, (3) a programmed lesson and self-appraisal, (4) an enrichment lesson, and (5) a mastery test. Students were exposed to the same science concepts four times. Experimental classes were taught using the new model, and control classes were taught using the original biology program. Pre-post tests were taken by the experimental and control classes during the first and last weeks of the semester. The tests consisted of both attitudinal and achievement tests. After analysis of the data, it was seen that eighty percent of the experimental group with IQ's above eighty nine achieved a mastery level of eighty percent of the test items answered correctly. Control groups at the IQ level were unable to attain mastery on any test. Experimental groups on other IQ levels also showed mastery of the concepts, while control groups did not. It was seen that after the program, the experimental groups held significantly more positive attitudes toward science than the control groups. The researchers concluded that the new teaching-learning model did accomplish its goals; it improved the level of achievement and attitudes of the culturally deprived students, while still offering challenge and learning opportunity to those not deprived. They further suggested that the individualized approach to the material may have accounted for the positive change in attitude of the students in the experimental groups.

Crawley, Frank E., and Krockover, Gerald H., "Attitudes of Uninvolved Students in Classrooms of Preservice Secondary-Science Teachers: A Modular Approach," School Science and Mathematics 79(4):317-321, April, 1979.

A total of forty one science students were the subjects of a study of a training program designed to help student teachers identify students showing neutral or negative science attitudes, and to involve them in classroom activities. The students were observed by ten student teachers over a period of seven to sixteen days. An instructional module was constructed to help student teachers gain the needed skills to identify and help uninvolved students. Four attitudes related to scientific literacy were identified by the student teachers: curiosity, inventiveness, critical thinking, and persistence. A chart was made to record each student's daily attitudinal behaviors. One of three marks was entered on the chart for each of the four behaviors identified: +(approach), -(avoidance), and 0(Neutral). Three to five students with attitudinal problems were identified and observed for a period of two weeks. At the same time, the student teachers looked for instructional alternatives which would provide more opportunities for the students to demonstrate positive attitudes. The student teachers kept a record of which activities were successful and not successful in initiating the behaviors of curiosity, inventiveness, critical thinking, and persistence. It was discovered that activities in which students took more responsibility tended to promote positive attitudes. Activities that restricted individual input or were too advanced tended to promote negative attitudes from uninvolved students. The student teachers noticed that uninvolved students had certain characteristics in common; they lacked self-confidence, sought teacher/peer group recognition, felt science was unimportant to their life goals, and were inattentive and temperamental. After compiling the results of the observations and descriptions, it was concluded that only after instruction is altered so that uninvolved students took an active part in the learning process, did they respond.

Story, Lloyd, and Brown, Iva D., "Investigation of Children's Attitudes toward Science Fostered by a Field-Based Science Methods Course," Science Education 63(5):649-654, October, 1979.

Two hundred eighty four fourth, fifth, and sixth grade students enrolled in four public elementary schools in the city of Hattiesburg were the subjects of a study designed to measure the effects of activity-centered science lessons taught by student teachers on the attitudes of upper elementary grade children toward science. The experimental groups were taught activity-centered science lessons over a two-year period by student teachers in addition to their regular science program. The control groups were taught similar lessons in mathematics, and received science instruction only from their regular classroom teacher using the conventional textbook method. An attitude inventory toward science was developed for use in the study. When the data were analyzed, a significant difference was found between the control and experimental groups. The experimental groups showed significantly more positive attitudes toward science than the control group. The experimental groups felt that science was more fun and not as difficult as the control groups. The authors concluded that the study indicated that a carefully planned and supervised early exposure program in science for student teachers did produce benefits in terms of affective behaviors of students toward science as a subject.

Robinson, James T., "Student Attitudes toward Science Courses in Test Schools Using Human Sciences," Journal of Research in Science Teaching 17:231-241, May, 1980.

The Human Sciences Program was an experimental, interdisciplinary curriculum. It was developed for three years of study by ten through fourteen year olds, taking subject matter from the behavioral and natural sciences. The program was developed to have both immediate and future value for the students. It consisted of activities organized into instructional modules from which students chose the activities they wished to study. Students were allowed to study at their own pace. One of the goals of the Human Sciences Program was to develop positive attitudes toward the course and toward science as a way of attaining knowledge. The Science Questionnaire instrument was developed to see if this goal was attained. Beginning in the Fall of 1973 and ending in the Spring of 1976, the materials for the Human Sciences Program were tested in seven schools. Four hundred two eighth-grade students were the subjects of a study designed to test the hypothesis that there was no difference in attitudes between students in Human Sciences Program classes and students in other eighth-grade sciences as measured by answers to the Science Questionnaire. One half of the students were in Human Sciences classrooms. The other half of the students tested were in regular science classes in the test schools. Upon analysis of the data, Robinson rejected the hypothesis that there is no difference in attitudes of eighth-grade students in Human Sciences classes and other eighth-grade science classes toward their science course as measured by the Science Questionnaire. The author discovered that Human Sciences students rated their course significantly more positive in terms of evaluation, value, activity, and interest. Robinson concluded that the goal of Human Sciences to help students develop and maintain positive attitudes toward this course was met.

Dillashaw, F. Gerald, and Okey, James R., "The Effects of a Modified Mastery Learning Strategy on Achievement, Attitudes, and On-Task Behavior of High School Chemistry Students," Educational Resources Information Center,Ed 201.515, n. pub., n. city, April, 1981, 23 pages.

One hundred fifty six students from nine classes enrolled in first-year chemistry were the subjects of a study designed to assess the effects of a modified mastery learning strategy on achievement, on-task behavior, and attitude toward science. Each of the classes was assigned to one of three treatment groups. In Treatment Group One, students received no diagnostic or remediation activities. In Treatment Group Two, diagnosis and remediation were student-managed. In Treatment Group Three, diagnosis and remediation were teacher-managed. Achievement was measured by quizzes given at the end of each three units. Attitude was measured by a questionnaire given at the conclusion of the study. On-task behaviors were recorded weekly on a two-point scale. From analysis of the data, it was seen that the teacher-managed and student-managed mastery learning groups scored significantly higher on all achievement measures. It was also found that both types of mastery learning situations had a positive effect on on-task behavior compared to the group receiving no diagnosis or remediation. The authors concluded that the results did not support the idea that the mastery learning strategy would result in more positive attitudes. The writers suggested that this may have occurred because students who chose to take chemistry already have very positive attitudes toward the course.

Long, Joe C.; Okey, James R.; and Yeany, Russell H., "The Effects of a Diagnostic-Prescriptive Teaching Strategy on Student Achievement and Attitude in Biology," Journal of Research in Science Teaching 18(6):515-523, November, 1981.

Ninety three high school students enrolled in three Biological Sciences Curriculum Study (BSCS) biology courses were the subjects of a study designed to assess the effects of three types of use of diagnostic-prescriptive teaching methods on the achievement and attitudes of the students in biology. The three types of use were (1) student-managed diagnosis and prescription, (2) teacher-managed diagnosis and prescription, and (3) a control group receiving no diagnostic-prescriptive instruction. Outcomes were assessed by one attitudinal questionnaire and three achievement tests. When the data were analyzed, the researchers concluded that on all achievement measures, groups instructed by the teacher-managed diagnostic-prescriptive method scored higher; however, on attitudinal measures, groups instructed by the student-managed diagnostic-prescriptive method scored more positively.

Friend, Harold, "The Effect of Science and Mathematics Integration on Selected Seventh Grade Students' Attitudes Toward and Achievement in Science," School Science and Mathematics 85(6):453-461, October, 1985.

One hundred eight New York City seventh graders, divided into four classes, were the subjects of a study that measured the effect of science and mathematics integration on students' attitudes toward science and achievement in science. Two classes consisted of students with standardized reading and mathematics scores at least two years above grade level, and two other classes consisted of students with standardized reading and mathematics scores on grade level. The Science Attitudes Appraisal and the Test of Physics Facts and Principles were administered to the students. One class with students' standardized reading and mathematics scores at least two years above grade level, and one class with students' standardized reading and mathematics scores on grade level, followed the science and mathematics integration format. The same type of sample followed the nonintegrated science and mathematics format. The investigation lasted ten weeks. Students' attitudes toward science and knowledge of specific physics facts were tested again using the Science Attitude Appraisal and the Test of Physics Facts and Principles. It was discovered upon analysis of the data that integrating science and mathematics did not result in a more positive attitude toward science for students with standardized reading and mathematics scores at least two years above grade level. Students taught by the nonintegrated method did not score any significant increase on the total Appraisal. When the data were analyzed comparing achievement in science of students who had science and mathematics integrated with achievement in science of students who were taught using the nonintegrated format, it was discovered that students with standardized reading and mathematics scores at least two years above grade level who had science and mathematics integrated showed significantly greater achievement in science than similar students who were taught by the nonintegrated format.

Kyle, William C.; and others, "An Implementation Study: An Analysis of Elementary Student and Teacher Attitudes toward Science in Process-Approach vs. Traditional Science Classes," Educational Resources Information Center, Ed 275 540, n. pub., n. city, March, 1986, 23 pages.

The purpose of this study was to assess and analyze attitudes toward science of students and teachers in Science Curriculum Improvement Study (SCIS) classes compared to students and teachers in non-SCIS classes. SCIS was a curriculum that emphasized inquiry-oriented, process-approach to the teaching of science. Two teachers from both SCIS and non-SCIS classes in grade two through six were chosen for the study. Two hundred twenty eight SCIS students and two hundred twenty eight non-SCIS students made up the student sample. Data were collected by the administration of the Student and Teacher versions of the Preferences and Understandings questionnaire. Upon analysis of the data, the researchers found that SCIS and non-SCIS teachers had similar attitudes to science. However, students in the inquiry-oriented, process-approach science classes had significantly more positive attitudes to science compared to students in traditional science classes that were textbook oriented. The authors concluded that student attitudes toward science were affected by the type of science taught.

## SUMMARY

Different authors defined "attitudes toward science" in many different ways. This study dealt with four main categories of definitions: scientific interests, scientific attitudes, attitudes toward the subject matter of science, and attitudes as affected by teaching method. (Haladyna and Shaughnessy, 1982)

"Scientific interests" referred to those interests that students have in common with scientists. (Haladyna and Shaughnessy, 1982) Hasan found the cultural variables did not significantly differentiate between high and low science interest students. The author did, however, find that instructional, outer motivational, and inner motivational variables had significant effects on the science interests of students. Lazarowitz sought to find specific reasons for students' interests in science. The writer found that the two top reasons for students' scientific interests were liking to go outdoors, and liking to see things live and grow. Lazarowitz found that the major reasons given for disliking science were related to a teacher's way of teaching and to the teacher as a person.

"Attitudes toward science" have also been called "Scientific Attitudes". "Scientific Attitudes" referred to a student's approach to thinking about science, to a cognitive attitude, or to a belief about thinking. (Haladyna and Shaughnessy, 1982) Moore (1971) came to four conclusions based on data gathered: (1) Students neither strongly rejected nor strongly accepted scientific attitudes; (2) A lack of strong attitudes was demonstrated; (3) Students do not understand the difference between

science and technology; (4) Students do not understand explanations given as laws and theories. The author further stressed that the data indicated that development of specific attitudes in the United States needed more attention. In the Moyer study, it was concluded that the formation of positive environmental attitudes was not influenced by the science classroom. The writer indicated that the study did not satisfactorily identify the factors that relate to environmental attitudes. Novick and Duvdvani discovered that the school variables of school type and future specialization, and the student variables of sex, achievement level, and cultural background had significant effects on students' scientific attitudes. They found that school curriculum was the only variable that did not affect students' attitudes. In the Simpson and Troost study to measure student commitment to science, the authors identified home commitment to science as a strong positive correlate to student commitment to science. Harty, Anderson, and Enochs (1984) indicated that in the study of fifth-grade interest in science, attitudes toward science, and reactive curiosity, they found significant positive correlations between curiosity and scientific attitudes, and between interest in science and scientific attitudes. They emphasized that students rated activity-oriented items the highest. The authors suggested that from the data, it appeared that all students preferred active involvement over passive involvement. In a later study, Harty, Beall, and Scharman (1985) established that a positive correlation existed between achievement in science and scientific attitudes. They stressed that the classroom

teacher could have a great influence on the positive development of scientific attitudes. The authors suggested that classroom interaction should reflect the relationship of cognitive development to scientific attitudes.

In the literature, "attitudes toward science" has often been used to refer to attitudes toward the subject matter of science. These are attitudes that are direct outcomes of schooling. (Haladyna and Shaughnessy, 1982) Two distinct types of research are recognizable: multiple variable research and research on learning environment variables.

Multiple variables research examines the relationships of many types of variables to attitudes toward the subject matter of science. In the Wick and Yager study, four conclusions were made concerning the relationships between attitude variables: (1) There was a marked decrease in course attitude for a portion of any group of students; there was not a similar group that showed a matched gain; (2) The classroom teacher was a very important factor in determining attitude toward the subject matter; (3) Grade did not appear to be an important factor; (4) Student attitudes toward a science course tended to change over a period of time. Keeves examined the effects of the variables of home, school, and peer group on attitudes toward the subject matter of science. The author found that gains in achievement made a large contribution to attitudes of liking science. Other variables shown to have an important influence were gender, participation by friends in science activities, and interaction between teacher and student. In a study that examined

the relationships of pupil and teacher personality characters to attitudes toward physics, Gardner identified a large decline in the enjoyment of physics shown by most students. One group that maintained a high level of enjoyment was intellectual, achievement-motivated students paired with intellectual, achievement-pressing teachers. Other students with other types of teachers showed a decline. Gardner concluded that competitiveness and achievement were the most significant teacher and pupil characteristics. High achievement pupils tended to best maintain a positive attitude when paired with teachers who scored high on competitiveness. Low achievement pupils did best in an atmosphere of low competitiveness. The writer further stressed that teacher and pupil effects appeared to be more powerful than effects caused by different instructional materials. Schafer and Vargo in a study of role-specific pupil-teacher compatibility, noted a significant correlation between gender and attitudes toward the subject matter of science. Female students were associated with more negative attitudes than their male counterparts. A significant positive correlation was also found between originator control compatibility and student attitude. This implied an agreement as to who should originate or initiate an interpersonal exchange. The authors concluded that in order to create a suitable learning environment, control behaviors of teachers and students must be resolved.

In the Haladyna, Olsen, and Shaughnessy (1982) study, relationship of student, teacher, and learning environment variables to attitudes toward the subject matter of science were examined. The researchers

concluded that exogenous student variables did not affect attitude, and that the variables of sense of importance of science, level of fatalism, endogenous teacher quality, and learning environment were strongly related to attitude. The authors expressed that students showed a desire to have satisfaction with the work they do, to be in a positive classroom environment, and to be instructed in an organized manner. Findings from further research on the correlates of class attitudes toward the subject matter of science by Haladyna, Olsen, and Shaughnessy (1983) supported the findings from their previous study. Again, the variables of the sense of importance of science, student fatalism, teacher quality, and learning environment proved to have significant correlations with attitudes. Student fatalism was negatively correlated. Importance of science, teacher quality, and learning environment variables were positively correlated. Talton and Simpson identified three variables in their study that showed a significant positive correlation with attitudes toward science. They were feelings toward self, family, and the classroom environment. Of the three sets of variables, the classroom environment variables proved to be the best predictor of attitudes.

Another portion of the research on attitudes toward the subject matter of science dealt specifically with learning environment variables. Learning environment variables described the setting and context of the instructional program. (Haladyna, Olsen, and Shaughnessy, 1982) Lawrenz (1975) examined the relationship between science teacher characteristics as part of the learning environment and student attitude. The four

teacher characteristics that ranked highest were formality, self improvement, knowledge of science processes, and goal direction. Formality was negatively correlated with attitude. Self improvement, knowledge of science processes, and goal direction were positively correlated with attitude. In the Ward study of the relationship between class size and student attitude, no evidence was found to support the idea that positive attitudes toward science were linked to smaller class size. However, a significant positive correlation was found between achievement and class size. Ward stressed that the strong positive association between achievement and attitude should not be ignored. The author suggested that a chain might exist from class size to achievement to attitude. Lawrenz (1976) discovered that student perception of the learning environment was significantly related to students' attitudes toward science in biology and chemistry classes but not in physics classes. The author indicated that students in chemistry and physics classes enjoyed the challenge of a difficult class, but students in biology classes held negative attitudes toward subject matter viewed as too difficult. The researcher pointed out that Friction and Favoritism were negative predictors of attitude in all classes. Ward concluded that students work best in a cooperative rather than competitive atmosphere. It was stressed that these factors are very important because they could be manipulated by the teacher to enhance positive attitudes.

In the Fraser study examining student attitudes toward sources of scientific information, it was discovered that favorable learning

environments created positive attitudes toward experiments as a source of information. Less favorable learning environments created positive attitudes toward experts, books, and teachers as sources of information. A favorable environment was defined as being more satisfying. A less favorable environment was defined as being more difficult, competitive, and disorganized. Fraser and Butts (1982) found that perceptions of greater classroom individualization were associated with more positive attitudes toward the subject matter of science. Okebukola concluded that the attitude of the student towards chemistry as a subject was the most important factor deciding student attitude toward laboratory work. The second most important factor was student participation. It was suggested that more participation in laboratory work produced a more positive attitude toward the laboratory.

The term "attitudes toward science" has also been used to refer to attitudes as they are affected by specific teaching methods or instructional activities. (Haladyna and Shaughnessy, 1982) In the Lowery study, student attitudes toward science were measured after experiencing a new unit called Animal Coloration. It was found that children who were taught the new Animal Coloration unit had significantly more positive attitudes toward science than similar children who were not taught with the material. "Invitations to Enquiry" was a set of enrichment lessons designed to accompany the BSCS curriculum. It was claimed that the lessons challenged and rewarded students as they participated in solving problems. Starr concluded that BSCS students who received the lessons

did not show significantly more positive attitudes than students who did not receive the lessons. Kempa and Dubé demonstrated that students instructed with England's new, revised, non-Nuffield chemistry syllabus held more positive attitudes than students instructed with the Nuffield Chemistry Course. These findings reversed an earlier study on the Nuffield Chemistry Course. The authors also concluded that lower ability students who could not understand the concepts of chemistry still derived satisfaction from learning the factual content. Factual content should be provided in a course for these students. In the LaShier and Nieft study, attitude changes in ISCS students compared to non-ISCS students were assessed. The data indicated a significant positive relationship between student attitude and cognitive achievement in ISCS. No differences in attitude between ISCS and non-ISCS students were noted. Vanek and Montean examined the effects of two curricula on student attitudes toward science: the Laidlaw Science Series, a textbook approach, and the Elementary Science Study, an activity-based approach. The researchers found no significant differences in attitude between the two approaches. They concluded that the data did not support the hypothesis that ESS classrooms differed from textbook-oriented classrooms. The authors emphasized that the data did show that the activity-oriented approach was just as effective as the textbook-oriented approach.

In the Knight and Dunkleberger study, students who participated in computer-managed self-paced laboratory instruction showed significantly more positive overall attitudes toward science than students who participated

in teacher-managed group-paced laboratory instruction. Sabar and Kaplan studied the effects of a new seventh-grade biology curriculum that consisted of five parts: (1) a lecture/discussion, (2) a laboratory, (3) a programmed lesson and self-appraisal, (4) an enrichment lesson, and (5) a mastery test. The effects of the new teaching model were compared to the effects of the original biology curriculum. The researchers concluded that students instructed by the new teaching learning model had significantly more positive attitudes toward science than students instructed by the original biology program. The authors pointed out that the individualized approach in the new material may have accounted for the positive changes in attitude. Crawley and Krockover examined a program designed to train student teachers to identify students showing neutral or negative science attitudes and to involve these students in classroom activities. They discovered that activities in which students took more responsibility tended to promote positive attitudes. They emphasized that activities which restricted individual input or were too advanced tended to promote negative attitudes in uninvolved students. In the Story and Brown study, the attitudinal effects of activity-centered science enrichment lessons taught by student teachers were measured. It was found that students receiving instruction through the activity-centered science lessons held significantly more positive attitudes toward science than students who did not receive instruction through the special activity-centered lessons. Robinson tested the hypothesis that there was no difference in attitudes between students in an experimental interdisciplinary

curriculum called the Human Sciences Program and students in regular science classes. Based on the data gathered, the hypothesis was rejected. The author found that Human Sciences students rated their course in significantly more positive terms than students in regular science classes. Robinson concluded that the Human Sciences Program did help students develop and maintain more positive attitudes.

In the Dillashaw and Okey study, the effects of a modified mastery learning strategy in chemistry were assessed. While both teacher-managed and student-managed mastery learning groups had superior scores on all achievement measures compared to learning groups not experiencing diagnosis and remediation, no evidence was found in the results to indicate that the mastery learning strategy resulted in more positive attitudes. The authors suggested that since chemistry was an elective course, the students may have had very positive attitudes to begin with. Long, Okey and Yeany also studied the effects of a diagnostic-prescriptive teaching method. They found that groups instructed by the teacher-managed diagnostic-prescriptive method scored higher on all achievement measures, while groups instructed by the student-managed diagnostic-prescriptive method scored more positively on all attitudinal measures. In the Friend study on the effects of science and mathematics integration, no evidence was found to indicate that science and mathematics integration resulted in more positive attitudes when compared to traditional science courses. Kyle studied the effects of the Science Curriculum Improvement Study (SCIS) classes on student attitudes toward science compared to non-SCIS

classes. The author discovered that students in the inquiry-oriented, process-approach SCIS classes had significantly more positive attitudes to science compared to traditional science classes that were textbook-oriented.

# CONCLUSIONS

## ATTITUDES TOWARD SCIENTIFIC INTERESTS

1. Students' scientific interests were positively affected by classroom activities that involve the outdoors and living things.
2. A teacher's manner of teaching and interpersonal disposition often negatively affected students' scientific interests.

## ATTITUDE AS AN APPROACH TO THINKING ABOUT SCIENCE

1. The state of students' scientific attitudes in the United States was very uncertain.
2. The distinction between science and technology was not understood by students.
3. Students lacked a basic knowledge of laws and theories.
4. Classroom content material did not affect students' scientific attitudes.
5. Students' plans for future specialization and employment in science had a positive effect on scientific attitudes.
6. Scientific attitudes were affected by gender, achievement level, and cultural background.
7. The attitudes toward science expressed in the home had a strong effect on students' scientific attitudes.
8. Classroom experiences that required active involvement had a positive effect on scientific attitudes.

9. Curiosity and interest in science were highly related to positive scientific attitudes.

ATTITUDES TOWARD THE SUBJECT MATTER OF SCIENCE

1. Students' attitudes toward the subject matter of science most often tended to decrease over a period of time.
2. Students' science attitudes were greatly affected by the classroom teacher.
3. Positive achievement in science had a positive effect on science attitude.
4. Attitudes of the peer group toward science influenced students' science attitudes.
5. Gender of the student affected science attitudes. Different gender effects were seen at different grade levels.
6. Students who achieved more in the classroom tended to prefer more competitiveness in the classroom. The opposite was true of low achievers.
7. Conflicts of control behaviors between students and teachers had a negative effect on attitudes.
8. Student fatalism had a negative effect on the student's attitudes.
9. Importance of science, teacher quality, and learning environment variables were positively correlated with students' attitudes.
10. Students' feelings toward self and the family were positively correlated with attitudes toward science.
11. A positive cause-and-effect chain might exist from class size

to achievement to attitude.

12. Friction and Favoritism in the classroom were negative predictors of attitude.
13. Positive attitudes toward experiments as a source of information were fostered by a learning environment that was more satisfying and less difficult, less competitive, and less disorganized.
14. Positive attitudes were enhanced by greater student perception of classroom individualization.
15. Positive attitudes toward chemistry laboratory work were produced by greater participation in laboratory work.

ATTITUDE AS AFFECTED BY TEACHING METHOD

1. Lower ability students who were unable to understand advanced concepts still derived satisfaction from learning factual content.
2. The use of computer-managed self-paced laboratory instruction had a positive effect on student attitude.
3. Many individualized science programs resulted in positive changes in student attitude.
4. Activities in which uninvolved students were required to take more responsibility tended to promote positive attitudes.
5. Activity-centered science lessons tended to foster positive attitudes.

## RECOMMENDATIONS

The following recommendations are made to science teachers because they have been shown by research to enhance positive student attitudes toward science.

### ATTITUDES TOWARD SCIENTIFIC INTERESTS

1. When possible, use classroom activities that involve the outdoors or living organisms.
2. Use available self-evaluation techniques to improve classroom teaching methods and interpersonal communications.

### ATTITUDE AS AN APPROACH TO THINKING ABOUT SCIENCE

1. Introduce printed and audiovisual material on science careers as part of the course.
2. Look for ways to allow all students some type of achievement in science.
3. Assign activities that encourage involvement of the home and family.
4. Choose classroom experiences that require active involvement of the student rather than experiences that require passive involvement.
5. Encourage natural curiosity and interest in science.

### ATTITUDES TOWARD THE SUBJECT MATTER OF SCIENCE

1. Assign class activities that allow peer groups to work together on science topics.

2. Keep competitiveness in the classroom to a minimum.
3. Quickly resolve conflicts of control behaviors between teachers and students.
4. Reduce fatalism by stressing to students that their work is the main factor affecting achievement in science.
5. Attend classes and workshops to further teaching expertise.
6. Continue efforts to reduce class size.
7. Take steps to keep friction and favoritism in the classroom to a minimum.
8. Maintain a high degree of instructional organization.
9. Do not assign work that is above the achievement level of the students.
10. Individualize instruction where possible.
11. Include laboratory instruction as part of the regular curriculum.

ATTITUDE AS AFFECTED BY TEACHING METHOD

1. Include in classroom instruction a mixture of science concepts and facts to be learned.
2. Involve computer-managed self-paced learning where possible.
3. Assign activities that require students to take more responsibility for their learning.
4. Create a curriculum that includes many activity-centered science lessons.

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BACKGROUND

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IV. Employment Experience

A. Substitute Teacher - Five years for Science only.

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C. Eighth Grade Science Teacher - Three years at Dickinson Middle School.

V. I am qualified to undertake this study because, as a Science teacher, I am very interested in learning what type of environment fosters positive science attitudes in students. I believe that attitude and achievement are closely related.